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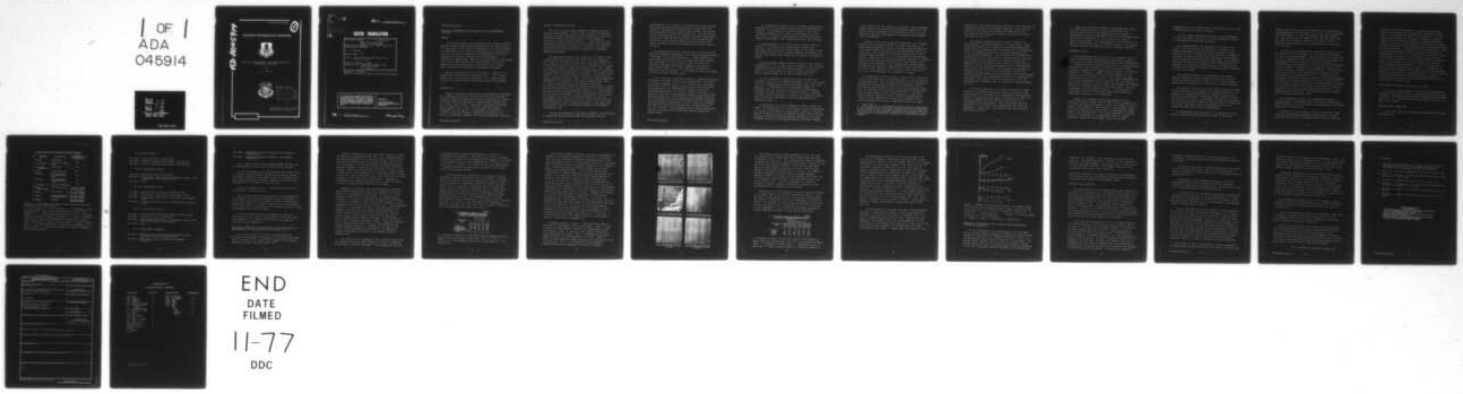

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by

W. Poninski

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By: W. Poninski

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PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

Wojciech Poninski MA

EPOXY AND POLYURETHANE PAINT COMPOSITIONS FOR AGRICULTURAL AIRPLANES

SUMMARY

In the article there has been presented the progress in paint materials used for agricultural airplanes that has been attained in this country in the course of twenty years. In connection with the development in the world of polyurethane paint materials there have been carried thru comparative investigations of the epoxy compositions currently being used with three different polyurethane compositions. There has been described the methodology of the tests which included also investigations of selected materials for protecting plants (insecticides etc.), as also under conditions that imitated the atmospheric influences.

The results achieved point to the better properties of the polyurethane compositions in comparison with epoxy ones, equally also in the presence the action of atmospheric factors as also the action of means of protecting plants (insecticides etc.).

INTRODUCTION

Lasquer coats play a large role in the assurance of durability of an airplane during use. Besides fulfilling the function of protection against atmospheric influences and besides the addition of certain decorative qualities to painted goods, lacquer coats must fulfill also a number of additional requirements important from a flight point of view. As a rule they must exhibit suitability for the work over a broad range of temperatures -50-+60°C, they must exhibit a significant resistance to the action of ultraviolet radiation, as well as a resistance to fuels,

greases, and hydraulic fluids.

The role of lacquer layers designed for agricultural airplanes is still greater. For they must constitute an effective protection for the airplane's structure against the powerfully destructive chemical and erosive action of the agents of protection of plants (insecticides etc.). Hence similarly also requirements set up for lacquer coats for agricultural aircraft especially pertaining to resistance to chemicals, are greater than those set up for paint coats of aircraft of a different destination (design).

The agricultural flight works carried on in Poland in (last) fifteen years (with the use of the CSS-13 and Li-2 airplanes) have shown that the lacquer goods used in this area (sphere) for the painting of aircraft show very little resistance to the action of agents of defence of plants (insecticides etc.) (SOR). There were produced then paint materials for flight based on traditional lacquer binders (nitrocellulose, oil-resinous, or phthalic), which did not assure sufficient chemical resistance of the colors and enamels produced from them. When at the end of fifteen years they proceeded to the production of the PZL-101 GAWRON there sprang up a need to import from the USSR chemically resistance perchlorovinyl enamels (based on chlorided polychlorvinyl), which had to constitute the anti-corrosive protection of these airplanes, as well as native corresponding ones worked out in a short time - the polyvinyl 101PS enamels - constituted markedly better protection against the action of SOR (insecticides etc.) than the traditional goods. However often still after a year's use there was confirmed not only a complete destruction of the coats from these enamels, but also of the metal elements of the airframe protected by them.

A marked and advantageous qualitative change in the possibility of protecting agricultural aircraft was constituted by the

undertaking in this country of the production of epoxy enamels. These goods relatively quickly attained a world level and, applied to the painting of agricultural aircraft, they gained the recognition of native and foreign users. The native epoxy enamels and especially their chemically resistance modification, constitute to this day the basic paint cover of agricultural aircraft as well as exibit effective and lasting protection against corrosion, for those aircraft used in various areas of the world.

For agricultural aircraft there are set up currently still higher requirements pertaining to their durability and resistance to theaction of SOR (insecticides etc). These requirements result among other things from the significant costs connected with the change of the old covers for new, as well as the constantly increasing assortment of agents of protection of plants (insecticides etc.), which sometimes included very chemically-active components. At the same time there are appearing new more perfect lacquer goods.

In the last year it has been possible to suddenly observe the development of enamels based on the polyurethanes. This group of chemical compounds, worked out in Germany even before WW-II after the finding of numerous applications in various branches of technology, in the fifteenth and sixteenth years found increasing application as a binder of lacquer materials. In a number of countries the polyurethane enamels are replacing other paint materials used for the painting of agricultural aircraft. In Czechoslovakia the polyurethane enamels have been introduced for the painting of agricultural aircraft (called) Z-37 CMELAK, and after their positive evaluation also for the painting of the L-410 aircraft. In East Germany and in Hungary agricultural aircraft are painted with polyurethane enamels during their general repair.

In the mentioned countries there are highly appreciated the values-in-use of polyurethane goods as covers for agricultural aircraft. At the same time also the analysis of the craft literature indicates that a result of the working out in the last years or new types of raw materials for the production of lacquer polyurethanes, their chemical resistance has increased.

The development of the Polish aircraft industry which is directed to the production of agricultural aircraft has determined that also in this country that (in the Debycki Color and Lacquer Factory) there has been commenced the production of highly valued polyurethane enamels for the needs of agriculutral flight.

The polyurethane enamels arise as a result of the reaction (polyaddition) of two or many organic isocyanates, with compounds containing more than two free hydroxyl groups. This reaction leads to a special network of high molecular polyurethanes, whose properties depend on the type of components used.

For the obtaining of lacquer goods there are used most frequently additions of toluene-di-isocyanate as well as polyesters with free hydroxyl groups obtained from adipic acid, glycol and glycerine. As advantages of the polyurethane enamels in comparison with the epoxies we mention their greater chemical resistance, greater resistance to abrasion, lack of a tendency to powder, and the production of craters, high decorative values (great lustre and smoothness) as well as the simplicity of removing soilings.

In publication [2] that is dedicated to paint covers for flight, the durability in use of polyurethane covers is determined at 5 years, but the epoxies at three years. Thanks to the working out of new types of polyisocyanates (alifatic ones) there has followed a further increase of chemical resistance of the polyurethanes as well as a significant diminution of their tendency

to turn yellow under the influence of sunlight. The polyurethane enamels based on the aliphatic polyisocyanate Desmodur N of the Bayer firm are recommended by the manufacturer [1] as the most chemically resistant from among all the lacquer goods hardened at room temperature.

Produced in this country under the initiative of the flight industry the polyurethane enamels for flight are based on the polyisocyanate Desmodur N and the polyester resins Desmophen 650 of the Bayer firm*. Evaluations of the technological and in-use properties of the enamels are being carried out by the flight industry and by the users of the first aircraft covered by these enamels. However in the Institute Lotnictwa (Institute of Flight) there have been undertaken investigations whose purpose is the evaluation and comparison of the polyurethane and epoxy enamels provided for the painting of agricultural aircraft from the point of view of their resistance to the action of SOR (insecticides etc.) and their durability under conditions of aging).

The evaluation of the resistance of paint coats to the action of SOR (insecticides etc.) is from many points of view (respects) a complicated task. This statement results from the difficulty of reproducing, during hurried laboratory investigations of such conditions of the operation of SOR on the coats as appears during use. The mentioned difficulties are connected with among others with the great number of SOR (insecticides etc.), with their varied chemical character, with the variable concentration (as a result of the evaporation of solvents and thinners) of the active substances (as a result of impurities due to the agents

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*The selection of these materials was carried out among others on the initiative of the Institute Lotnictwa (Institute of Flight) in the conviction that from among the many other raw materials for the production of polyurethanes, Desmodur N and Desmophen 650 give lacquer goods of the greatest suitability for agricultural flight purposes.

(insecticides etc) used previously), as well as connected with the simultaneous influence of climatic conditions. There does not exist up to this time any standardized methodology for the evaluation of the resistance of (paint) coats to the action of SOR (insecticidies etc).

The standard literature gives a number of methods of investigating the chemical resistance of lacquer coats. These methods have however the character of checking-investigations serving for the evaluation of the repeatability of the properties of the investigated material and not for the characteristic of the chemical resistance. In publications in the area of the resistance of coats to the action of certain chemical substances the evaluation of the resistance is carried as far as the determination and comparison of the influence of chemical substances of one or two selected properties of the simultaneously investigated paint materials. This influence is determined by comparing the time of use of the investigated coats in the necessary chemical agents till the appearance of a definite change of the properties of the investigated coats, or by comparing the magnitude of the changes of selected properties of the coats appearing after a definite time, of their use in chemical agents [3, 4, 5].

In the works undertaken in the Institut Lotnictwa (Flight Institute) the evaluation of paint coats to the action of SOR (insecticides etc) was based also on comparative investigations. During the evaluation of the native (this country's) coats, as a level of reference there was taken the properties of the polyurethane coats used abroad. There were carried out also comparisons of the properties of polyurethane coats with the properties of epoxy coats, used currently for the painting of agrucultural aircraft.

Agents for protection of plants (insecticides etc) used in the investigations as well as their concentrations were selected on the basis of recommendations of the Institut Agrolotnitswas (Agricultural Flight Institute) in Krasnodar while taking into consideration of the opinions of the users of agricultural aircraft. It was attempted to select such a set of agents that would represent SOR (insecticides etc) of different chemical character and different level of (chemical) activity.

EXPERIMENTAL PART

The investigations were carried on in two stages. In the first stage there were investigated the resistance of enamels to the action of several plant protecting agents (SOR) (insecticides etc) considered by agricultural aircraft users as chemically-active with regard to coats of paint, as well as (there was investigated) the durability of enamels under conditions that imitate atmospheric influences. Besides the native enamels - a polyurethane from the information group of the Debicki Color and Lacquer Factory (DFFL) and an epoxy - there were investigated also two foreign polyurethane enamels, which are used for painting of agricultural aircraft in Czechoslavakia, East Germany and Hungary, and have the reputation there as covers that assure a very good and durable protection against corrosion. The simultaneous investigation of native and foreign enamels made possible a comparative evaluation of these materials.

Changes in the makeup of the drying catalysts of the polyurethane enamel brought about by DFFL after the completion of the above mentioned investigations as well as a change in the set of SOR (insecticides etc) used currently in agricultural flight jobs have established the suitability of undertaking the second stage of the investigations. This stage contained an investigation of the resistance of a polyurethane enamel of changed (improved) composition and an epoxy enamel (of the same

composition as in the first stage) to the action of a set of SOR (insecticides etc) of current interest.

All the enamels discussed in this work were investigated as multi-layer paint sets, thus it is more sensible to speak of an investigation of sets than of enamels.

The investigation of the resistance of the sets to the action of SOR was based on the evaluation of changes of the external appearance of the paint coats, of changes of their weight, as well as of changes of adhesion as well as changes in resistance to bumps-occurring under the action of those agents at room temperature thus a period of 2000 hours. The investigations were carried out on specimens of an aluminum alloy PA7 of dimensions in agreement with PN-53/C-81513. The edges of the specimens were protected by additional painting with a chemically resistant epoxy enamel.

The external appearance was determined by the method of visual evaluation of changes observed in the coats on three specimens initially after the elapse of 2, 5, 10 and 14 days of aging in SOR (insecticides etc) and then at two-week intervals.

The changes of weight of the coats caused by the stay in SOR (insecticides etc) were determined in a manner analogous to the manner of the weight determination of absorbability of coats described in PN66/C-81521. Measurements were carried out after each 100 hours of stay of the specimens in SOR as well as after a ten day drying of the specimens that had been aged thru 2000 hours. As a result there was accepted the arithmetic mean of the results obtained from the three determinations.

The investigation and evaluation of the resistance of the coats to bumps were carried on with the help of the Dupont

apparatus in accordance with PN-54/C-81526, but the examination (investigation) of the adherence of the coats - was in accordance with PN64/C-81531. In both investigations the measurements were carried out after the elapse of 100, 200, 500, 1000, 1500 and 2000 hours of aging in SOR as well as after 10 days of drying at room temperature of the specimens that had been aged thru 2000 hours.

The method of invetigating the resistance of paint sets to the action of SOR (insecticides etc) used inthe second stage of the work was somewhat changed. There was given up the determination of the adherence of the coats because this investigation (in accordance with PN-64/C-81531) did not lead to any sort of differentiating of the resistances of the paint sets investigated, nor did it permit the drawing out of suggestions having to do with the chemical activeness of individual SOR. A further change in the second stage was constituted by the carrying on of the investigations at a temperature of 60°C. It made possible a significant shortening of the time duration of the investigations. The change of the aging temperature from room to 60°C was based on the results of reference work [6] on the resistances of plastics to the action of similar SOR, in which (work) there is stated the agreement of the results of investigations carried on a room temperature with the results of investigations at 60°C carried on in a significantly shorter time.

The temperature of 60°C as the temperature of aging in chemical agents is recommended also by the Soviet standard GOST 9355-60 which has to do with methods of investigating the chemical resistance of lacquer coats.

Investigation of the durability of the (paint) sets under conditions that imitate atmospheric influences (in the first stage) was carried out in accordance with the method worked out

in Institut Lotnictwa reference [7] allowing an approximate comparative evaluation of the atmospheric durability of paint coats. In the system for aging, the specimens of coats were subjected periodically to the action of destructive factors (agents) such as ultraviolet radiation, elevated temperature (65-70°C), as well as a three percent (3%) solution of hydrogen peroxide, which constituted simultaneously an oxidizing agent and a source of dampness. As specimens for the investigations there were anodized sheet-metal plates of aluminum alloy PA7T, of dimensions 100 x 300 x 1.5 mm covered by the (paint) sets being investigated. The border of the specimens is protected by a double cover of chemically resistent epoxy enamel. The time of aging of the specimens in the system amounted to 200 hours, which corresponds approximately to a half a year period of natural aging, and makes possible there being produced in the coats destructive changes characteristic of the beginning stage of aging. The evaluation of the durabilities of the (paint) sets being investigated under conditions imitating atmospheric influences was subjected to a visual evaluation of the level of destruction of the aged coats.

PLANT PROTECTING AGENTS (insecticides etc) USED

A list with characteristics of the plant protecting agents (insecticides etc) used during the investigations has been placed in Table 1. The plant protecting agents designated by an ordinal number from 1 to 5 were used in the first stage of the work, the rest in the second.

THE PAINT SETS INVESTIGATED

In the first stage of the work were investigated the following paint sets:

SRODKI OCHRONY ROSLIN STOSOWANE W BADANIACH POWŁOK

Lp.	Nazwa środka	Substancja aktywna	Stężenie substancji aktywnej stosowane w badaniach
1	Trawotox	wodzian chloralu	35%
2	Antyperz płynny 38	sól sodowa kwasu trójchloro-octowego	20%
3	Nawóz płynny dwuskładnikowy PK	fosforany potasu	40%
4	Valexon	związek fosforoorganiczny	0,1
5	Foschlor 50	0,0-dwumetylofosfonian — — 2,2,2-trójchloro-1-hydro-ksyetylu	2,5%
6	Foschlor 50	0,0-dwumetylofosfonian — — 2,2,2-trójchloro-1-hydro-ksyetylu	10%
7	Ciecz bordoska	zasadowy siarczan miedziowy	3%
8	Nawóz jednoskładnikowy N	saletra amonowa, mocznik	Stosowany w stanie dostawy bez rozcieńczania
9	Melipax	chlorowane terpeny	Stosowany w stanie dostawy bez rozcieńczania
10	Malation	0,0-dwumetylodwutiofosforan--1,2-dwukarbotoksyetylu	Stosowany w stanie dostawy bez rozcieńczania
11	Sumition	fenitrotion	Stosowany w stanie dostawy bez rozcieńczania

Table 1. A. Plant Protecting Agents (insecticides) used in the investigation of (paint) Layers.

B - name of agent; C - Active substance; D - Concentration of the active substance used in the investigations; E - liquid anti-doggrass 38; F - Liquid two-component fertilizer PK; G - Bordeaux mixture, H - Single component fertilizer N; I - Organic phosphorus compound M-O,O dimethyl phosphonium-2,2,2 trichloro 1 hydroxy ethyl (same as M), O - basic copper sulphate; P - amonium nitrate, urea, Q - chlorated terpenes; R - 0,0 dimethyl diphosphate 1,2 di carboxyl ethyl, S - phenyl-nitro-thione?; T - used in delivered state without dilution.

Set I, epoxy, native

1st layer - epoxy base color (7429-659-130)
2nd layer - chemical resisting epoxy enamel (7462-000-030)
3rd layer - chemical resisting epoxy enamel (7462-000-030)

Set II, polyurethane, native

1st layer - epoxy base color (7429-659-130)
2nd layer - polyurethane enamel from the information group of the Debicky Color and Lacquer Factory
3rd layer - ditto

Set III, Polyurethane, Czech

1st layer - reacting basis S-2008 with hardener S-6011
2nd layer - polyurethane layer U-2001 with hardener U-7060
3rd layer - polyurethane enamel-yellow U-2052/6400 with hardener U-7060
4th layer - polyurethane enamel-yellow U-2052/6400 with hardener U-7060

Set IV, polyurethane, native

1st layer - reacting basis S-2008 with hardener S-6011 (Czech)
2nd layer - epoxy basis color (7429-659-130)
3rd layer - polyurethane enamel from the information group of the Debicky Color and Lacquer Factory
4th layer - ditto

Set V, polyurethane, Hungarian

1st layer - reacting basis with symbol 59-12-35-214-400 with hardener of symbol 59-12-35-929-001
2nd layer - epoxy basis "reactive primer" with hardener "Resistan B"

3rd layer - polyurethane nenamel "Resistan" with hardener "Resistan 001"

4th layer - polyurethane enamel "Resistan" with hardener "Resistan 001"

Set I epoxy, based on native lacquer goods, has been used for many years as a paint cover for agricultural aircraft.

Set II polyurethane, was an experimental set, worked out by the Debicki Color and Lacquer Factory for the needs of flight. The enamel entering into the makeup of the set is based on the many function aliphatic isocyanate "Desmodur N" and the resin "Desmophen 650" - products of the Bayer firm.

Set IV is similar to set II. The difference lies in the introduction of a reactive base.

Set III Czech, used in Czechoslovakia and East Germany for the painting of agricultural aircraft is based on "Desmodur L" of the Bayer firm, but Set V Hungarian used for the painting of agricultural aircraft in Hungary is based also on raw materials of the Bayer firm. More precise data concerning the type of these raw materials has not been obtained.

In the 2nd stage there was investigated an epoxy set identical with a set from the first stage as well as the native polyurethane Set II, composed with the use of an enamel of modified catalyst composition.

INVESTIGATION RESULTS OF THE RESISTANCE OF THE SETS (paint) TO THE ACTION OF SOR (insecticides and fertilizers etc.)

In the first stage of the work it was confirmed that Foschlor and Two-Component Fertilizer in the course of the whole period of aging, did not cause visilbe changes in the external appearance of any of the five (paint) sets.

Valexon caused light matting of the sets whereby its level was practically identical for all sets. The differentiating of the external appearance of the sets as a result of the action of SOR could be observed only in the cause of (Grass Poison) and (Anti Dog-Grass). In both these agents the greatest changes of external appearance occurred to the specimens of Set III (polyurethane, Czech), the least however to (on) Set I (epoxy, local?). In Trawotox Set III was underwent to a blistering after 24 hours, however Set I, after almost 900 hours, (after 100 hours it showed a change of color from cream to light brown). Similarly a blistering of the remaining Sets (II, IV & V) under the action of Trawotox appeared after 700-800 hours of aging.

Changes of the weight of the layers under the influence of SOR (insecticides and fertilizers etc) confirmed in the first stage of the investigations showed that the Sets I, II, IV & V underwent an absorbtion in these agents. The maximum weight increment of the coats of these sets confirmed after 2000 hours of stay in the chemically active liquids used, amounted to 2-5% (depending on the kind of SOR and the paint set). An investigation carried on a after drying ten days at room temperature of the specimens aged thru 2000 hours showed minimum decrements of weight (chem-scrubbing) of these sets reaching 1%. Moreover Set III (Czech) in the beginning period of the aging (thru several hundred hours) showed an increment of coat weight, but then a fall to negative (decrement) values. After the completion of the aging and drying for 10 hours at room temperature the weight decrement amounted to - depending on the type of SOR - 2.5-3%. This investigation showed that Set III underwent a chemical-scrubbing in the SOR at a level greater than the remaining sets.

The results of the investigation from the first stage of the work showed a relatively small influence of SOR on the adhesion of the coats to the base (airframe). This adhesion for all five

sets before aging in the SOR corresponded to a level of 4 according to PN-64/C-81531. After 2000 hours of stay in SOR and a drying for ten days at room temperature the adhesion of the layer had decreased for all sets and independently of the type of SOR, to a level of 3 (three). As a result of this, the investigation of adhesion did not distinguish the resistances of the (paint) sets to the action of the SOR.

A differing paint set resistance to the action of SOR was confirmed during the determination of the resistance to knocks. After 2000 hours of stay in these agents and ten days of drying at room temperature the greatest resistance to bumps was shown by Set IV, i.e., the native polyurethane set with a reacting basis, the least resistance, however, by Set III (Czech), which showed itself to be worst also in investigations of external appearance and was showing the greatest coat weight decrements under the influence of SOR. The remaining three sets after investigation in SOR were showing a close (nearly equal) resistance to bumps. The results of the investigation of resistance to bumps of the (paint) sets after 2000 hours of aging in SOR and ten days of drying have been presented in Table 2.

Tablica 2

ODPORNOŚĆ NA UDERZENIE ZESTAWÓW MALARSKICH STARZONYCH W ŚRODKACH OCHRONY ROŚLIN PRZEZ 2000 GODZIN

Środki ochrony roślin	Zestaw malarski				
	I	II	III	IV	V
	kGcm	kGcm	kGcm	kGcm	kGcm
Foschlor	25	30	15	50	30
Antyperz płynny	25	30	25	30	40
Nawóz płynny	30	50	20	50	50
dwuskładnikowy PK					
Valexon	30	30	10	40	35

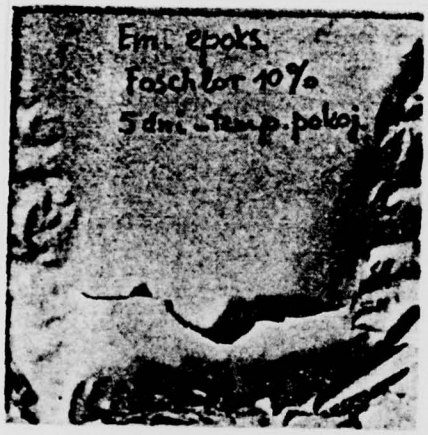
A - Paint-set resistance to bumps after aging in plant protection agents (SOR), insecticides, fertilizers, etc.); B - SOR; C - paint set; D - Anti-doggrass-liquid; E - liquid manure; F - two-component PK.

In the second stage of the work, during the investigation of changes of the external appearance of the (paint) sets aged in SOR, there was confirmed a significant differentiation of the level of chemical activity of these agents as well as a relatively small differentiation of the chemical resistance of the compared sets. There most chemically-actively operated on the coats, Foschlor and Bordeaux mixture. Both of these agents after several hours of aging already were causing a deformation of the coats of the paint sets, whereby Phoschlor caused destruction moreover of the duralumin sheet metal that constituted the basis for the paint set. There was carried out additionally an analogous test at room temperature and it showed that in the case of Phoschlor similarly "in the cold state" at a concentration amounting to 10% there occurs a swift destruction of both investigated sets and a dissolving of the basis. Markedly less changes of external appearance under the influence of Phoschlor was exhibited by the polyurethane (paint) set. In the case of Bordeaux mixture the resistance of both sets was close. The coat changes discussed here bear witness to the insufficient resistance of the sets examined to the action of Foschlor and Bordeaux mixture as well as make impossible the investigation of other properties of these coats after a long lasting aging in the discussed SOR (insecticides, fertilizers, etc.). The state of the investigated coats after aging in Foschlor and Bordeaux mixture is illustrated on diagrams 1-6.

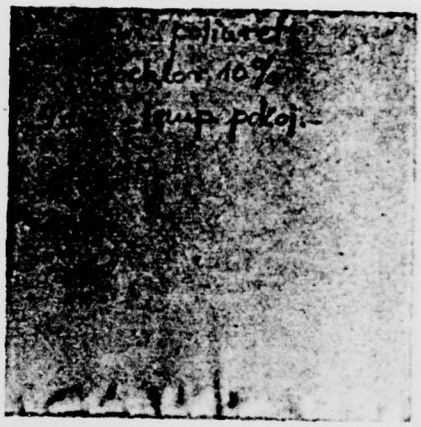
(Diagrams captions); Diag. 1. Epoxy set after aging in Foschlor at a temperature of 60°C for 18 hours. Diag. 2. Polyurethane set after aging in Foschlor at a temperature of 60°C for 18 hours. Diag. 3. Epoxy set after aging in Foschlor at room temperature for 5 days. Diag. 4. Polyurethane set after aging in Foschlor at room temperature for 5 days. Diag. 5. Epoxy set after aging in Bordeaux mixture at a temperature of 60°C for 118 hours. Diag. 6. Polyurethane set after aging in Bordeaux mixture at a temperature of 60°C for 118 hours.

Rys. 1. Zestaw epoksydowy po starzeniu w Foschlorze w temp. 60 °C przez 18 godzin

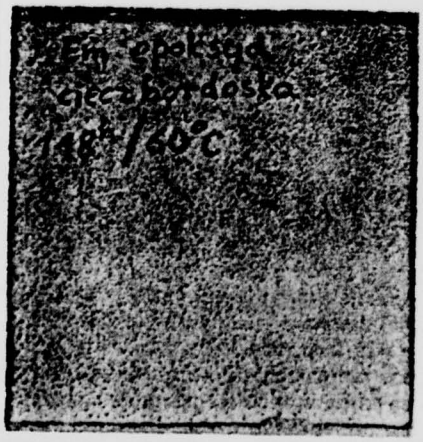
Rys. 2. Zestaw poliuretanowy po starzeniu w Foschlorze w temp. 60 °C przez 18 godzin



Rys. 3. Zestaw epoksydowy po starzeniu w Foschlorze w temp. pokojowej przez 5 dni



Rys. 4. Zestaw poliuretanowy po starzeniu w Foschlorze w temp. pokojowej przez 5 dni



Rys. 5. Zestaw epoksydowy po starzeniu w cieczy bordoskiej o temp. 60 °C przez 118 godzin

Rys. 6. Zestaw poliuretanowy po starzeniu w cieczy bordoskiej o temp. 60 °C przez 118 godzin

The changes in the external appearance of both sets under the influence of the remaining SOR are insignificant and reduce to changes of color (hue). The polyurethane set aged in Sumithion, malathion, and Melipaks, changed hue from yellow to beige, but the epoxy set after aging in Melipaks - from cream to light brown. Aging in Single Component Fertilizer N did not cause visible changes in the external appearance of either set. The changes of external appearance of the sets aged in Bordeaux mixture, Malathion, Sumithion, Melipaks and one Component Fertilizer N do not distinguish the resistances of the investigated paint sets to the action of SOR. Only the investigation in Foschlor indicates a greater (although insufficient) resistance of the polyurethane set in comparison with the epoxy.

The results of the investigation of knock resistance obtained in the second stage of the work are presented in Table 3. From the numerical data placed in Table 3 there results that aging in SOR leads to a significant drop in the resistance of the sets to knocks. The magnitude of this drop is more dependent on the kind of paint set and the time of aging than on the type of SOR used in the investigation. In all SOR the polyurethane set showed markedly greater resistance to bumps than the epoxy set.

Tablica 3

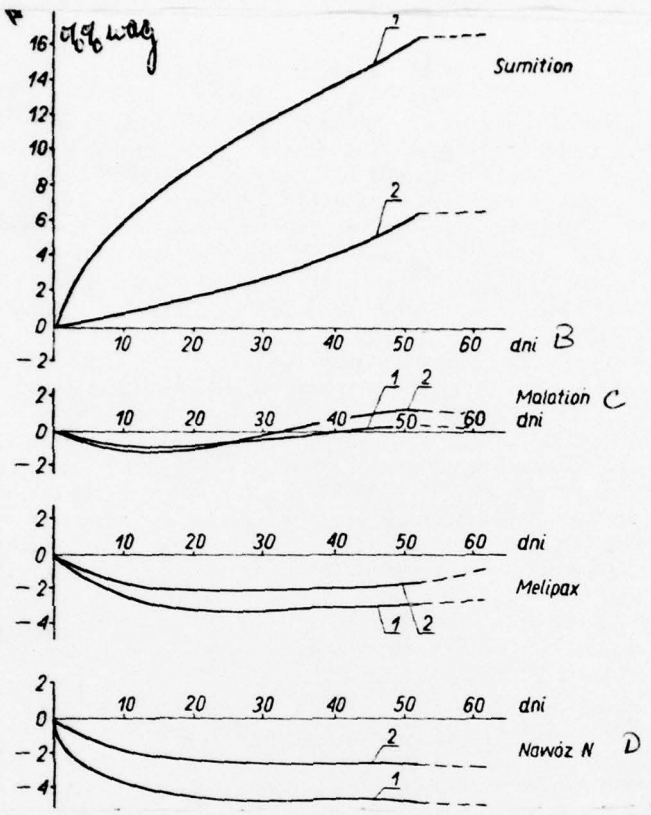
A ODPORNOŚĆ NA UDERZENIE ZESTAWÓW MALARSKICH STARZONYCH W ŚRODKACH OCHRONY ROŚLIN W TEMP. 60°C

Środki ochrony roślin B	Odporność na uderzenie, kGcm C					
	zestaw poliuretanowy D			zestaw epoksydowy E		
	czas starzenia dni F			czas starzenia dni F		
	17	34	52	17	34	52
G Nawóz N	47	35	35	47	20	15
Sumition	50	45	35	50	25	15
Malation	50	47	35	50	25	20
Melipax	50	45	30	50	35	20

A - Reistance to knocks of paint sets aged in plant protection agents (SOR) at a temperature of 60°C; B - Plant protection agents (SOR); C - resistance to bumps, kGcm; D - polyurethane set; E - epoxy set; F - time of aging in days; G - fertilizer (manure) N.

The investigation carried on in the second stage of the work in re the changes of coat weight under the action of SOR showed that the character of these changes, that is, the increment of decrement of coat weight, depends on the type of SOR but the magnitude of changes - (depend on) the paint set (diag. 7). Aging in Sumithion caused a significant increment in the weight of both investigated sets, proportional to the time of aging. After 52 days of aging this increment amounted to more than 16% for epoxy coats, but for polyurethane coats - more than 6%. Aging in Melipaks and in One Component Fertilizer N caused a fall in weight of the coats of both sets. This drop underwent a stabilization after a period of 20 days of aging and did not exceed 5%. Another characteristic of the coat weight changes was observed during aging in Malathion. In the beginning period of the investigation (up to around 30 days) both sets exhibited a small (up to around 1%) drop in coat weight, but in the second period - similarly a small increment of weight. During aging in malathion slightly less changes of weight were shown by the epoxy set.

The investigation in Sumithion, Melipaks, and One-Component Fertilizer N showed that in changes of coat weight under the influence of the stay in these agents are markedly less in the case of polyurethane coats visa vis epoxy. Assuming that the changes in coat weights of both sets in Melipaks are so close that they do not distinguish these sets one can state that in the investigation under discussion the polyurethane set showed significantly less changes of weight under the influence of SOR.



Diag. 7. Changes of polyurethane and epoxy coat weights caused by the action of SOR (plant protection agents, insecticides and fertilizers, etc.) as a function of the time of the action. 1 - epoxy set, 2 - polyurethane set, - - - changes of the coat weights during drying at room temperature.
A - weight; b - days, c - malathion; d - fertilizer N.

RESULTS OF INVESTIGATION UNDER CONDITIONS THAT IMITATE THE ATMOSPHERIC INFLUENCES

In the investigation of the durability of the sets under conditions that imitate atmospheric influences the smallest aging changes were shown by set V (Hungarian) which as a result of a two-hundred hour test showed only a partial loss of lustre. The greatest aging changes - loss of lustre, a few small blisters shrivelling of the coats in isolated places as well as separation of the cover from layers placed more deeply on the modest-sized

surface of the specimens - were confirmed in the case of the epoxy set. The remaining sets II, III and IV were characterized by nearly same aging changes (by a partial loss of lustre and by several individual blisters). These changes appeared on Set IV somewhat later than on Sets II and III.

The results obtained of the aging investigations distinguished the individual sets but simultaneously indicate their significant durability under conditions of atmospheric aging.

DISCUSSION OF THE RESULTS

The durability of the investigated (paint) sets evaluated on the basis of a speeded-up test of atmospheric aging permits us to state that the most resistant is the Hungarian polyurethane set. The remaining polyurethane sets (two native and one Czech) have been evaluated as equivalent and somewhat worse in comparison with the Hungarian ones. Less durability under conditions of aging in comparison with the polyurethane sets was shown by the epoxy set. Differences of durability confirmed in the laboratory of the polyurethane sets and of the epoxy set indicated noticeable and possessing-practical-significance differences of durability under conditions of natural aging in the atmosphere.

On the basis of investigations of the sets under conditions of the direct operation of SOR carried on in the first stage of the work, one can state that the least resistance to the action of chemical agents was shown by Set III (Czech polyurethane). Coats of this set showed the greatest level of destruction in the investigation of external appearance, the least resistance to knocks as well as the greatest ease of chemical-scrubbing out of components by liquid SOR. The small resistanee of this set in comparison with the other polyurethane sets can be explained by the difference in the type of resins that constitute the membrane-producing substance of the enamel. The Czech set is based on

Desmodur L, whereas the native is based on Desmodur N, which according to reference publication [1] assures greater chemical resistance.

The epoxy set was shown to be more resistant to the action of the SOR used in the first stage of the work which set in Trawotox and Antiperz showed a lower level of destruction than the polyurethane sets.

A comparison of the investigation results of the native polyurethane Sets II and IV confirms the belief widespread abroad (not credited in this country) about the suitability of the use of a reacting basis in the polyurethane sets.

A comparison of the investigation results of the native polyurethane sets with the results of the investigation of the Czech set confirms the rightness of the selection of Desmodur N and Desmophen 650 as raw materials for the production of polyurethane enamels for agricultrual aircraft.

In the investigations of the resistance of paint materials to the action of the SOR (insecticides, fertilizers, etc.) carried out in the first stage of the work, there were valued the native polyurethane sets composed with the use of an enamel that hadn't been fully polished (debugged) (coming from the information group) and from this point of view the evaluation of the resistance of these sets to the action of the SOR (plant protection agents) is less decisive than that obtained in the second stage of the work. All the same the investigation results obtained make it possible to state that the native paint sets compared with the foreign ones from the point of view of capability for anticorrosion protection, exhibit in general very close or better properties.

The results of all the investigations of the resistance of the polyurethane and the epoxy sets to the action of SOR that were

carried out in the second stage of the investigations point to the greater resistance of the polyurethane set. One may suppose that a polishing (improvement) carried out in the period between the first and second stage ofthe investigations of the native polyurethane enamel, corrected the quality of this item.

Taking into consideration the investigation results of the durability under conditions imitating the atmospheric influences (under which (conditions) the polyurethane set showed a greater durability than the epoxy) as well as the close or greater resistance of the polyurethane set confirmed in the first stage of the work - to the action of SOR in comparison with foreign sets, one can state that the native polyurethane set exhibits a great suitability as a paint cover for agricultural aircraft and in this regard it exceeds somewhat the epoxy set.

The differences discussed here in effectiveness at anti-corrosion protection, although marked, are less than the differe differences between the protection effectiveness of epoxy and polyvinyl sets.

Both sets investigated showed a good resistance to the action of Melipaks, malathion, One-Component Fertilizer N, but the polyurethane set also to the action of Sumithion, in which the epoxy set showed a significant absorbtion.

The investigations carried out showed that there exist SOR (plant protection agents, i.e. insecticides, fertilizers, etc.) which in a relatively short time cause destruction of the polyurethane and epoxy covers and in this regard (due to this) must not be used in aircraft protection with these covers. Among such agents there belong (from among those investigated in the work above), Foschlor, Travotox, and Bordeaux mixture.

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